UNIVERSITI SAINS MALAYSIA

Peperiksaan Semester Pertama
Sidang Akademik 2003/2004

September/Oktober 2003

IEK 101/3 – PENGHITUNGAN PROSES KIMIA

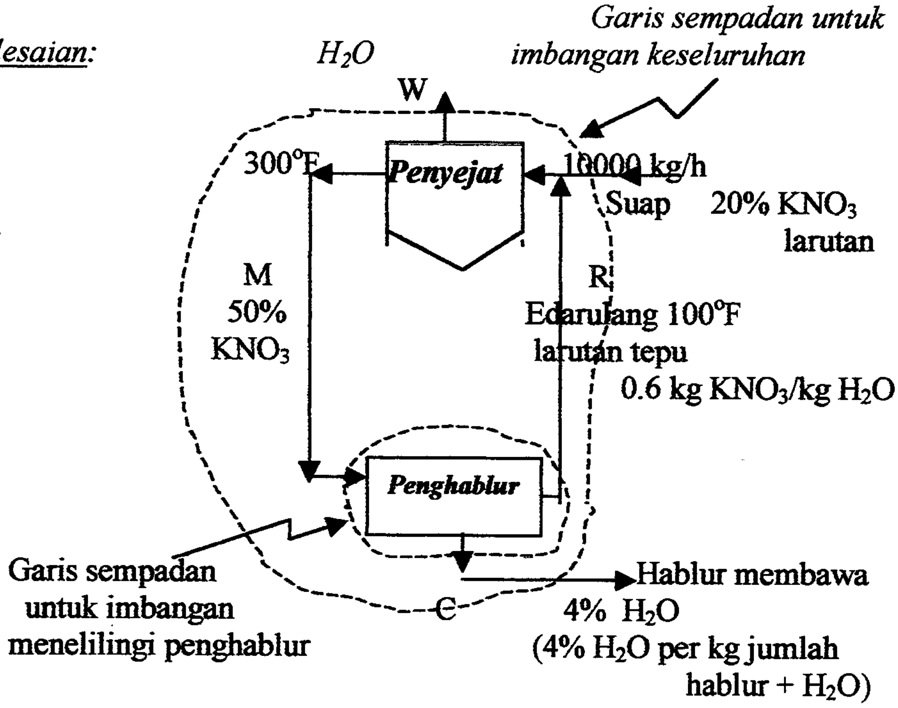
Masa : 3 jam

Sila pastikan bahawa kertas peperiksaan ini mengandungi ENAM BELAS (16) mukasurat yang bercetak sebelum anda memulakan peperiksaan ini.

Wajib jawab soalan 5 dan 6. Pilih 3 dari soalan 1 hingga 4. Semua soalan mesti dijawab dalam Bahasa Malaysia.

1. Gambarajah berikut merupakan satu operasi yang melibatkan satu penyejat dan satu penghablur. Data operasi adalah seperti ditunjukkan. Kirakan kadar arus edarulang R dalam unit kg/h.

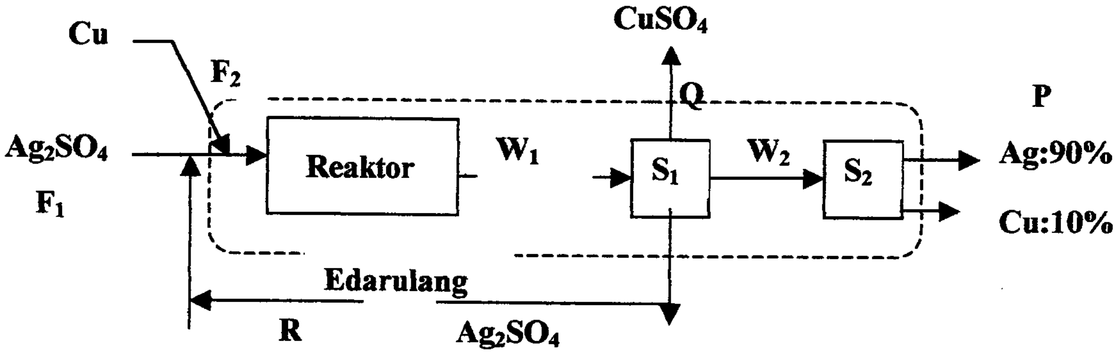
<u>*Penyelesaian:*</u>



Untuk arus edarulang,
Dasar: 1 kg H_2O

2. Argentum logam boleh didapati daripada bijih sulfida melalui proses memanggang untuk menjadi sulfat, melarutleleh dengan air, dan memendap argentum dengan kuprum. Dalam gambarajah berikut, bahan yang meninggalkan pemisah kedua mengandungi 90% argentum dan 10% kuprum. Untuk 1000 kg bahan dikeluarkan dari S_2, tentukan amaun Cu. Jika tindak balas berlaku hingga 75% sempurna berdasarkan bahan tindak balas terhad Ag_2SO_4, apakah arus edarulang dalam unit kg ?

	Ag_2SO_4	+	Cu	$\rightarrow$	2Ag	+	$CuSO_4$
Berat molekul	312		63.5		107.9		159.6



Dasar: 1000 kg bahan keluar dari S_2

Dari imbangan keseluruhan: zat ikat : Ag, $SO_4^{=}$

3. Karbon monoksida pada 200°C dibakar pada tekanan atmosfera dengan udara kering pada 500°C yang dibekalkan 90% kelebihan daripada yang diperlukan secara teoretis. Hasil-hasil pembakaran meninggalkan kamar tindak balas pada 1000°C. Berapakah yang dikelurkan dari tindak balas itu dalam unit kcal/kg-mol CO terbakar. Anggapkan proses pembakaran itu sempurna dan N_2 *hadir didalam udara.*

Dasar : 1.0 kg-mol CO.

$$CO(g) + (½)O_2(g) = CO_2(g)$$

Data: $\Delta H_{25} = -67636$ *kcal*

Untuk entalpi bahan-bahan tindak balas (H_R) *relatif dengan keadaan standard pada 25°C, gunakan* C_{pm} *= muatan haba molal purata antara 25°C dengan T°C.*

Bagi CO: $C_{pm} = 7.017$ *cal/g-mol-K*

Bagi udara: $C_{pm} = 7.225$ *cal/g-mol-K*

Bagi CO_2*:* $C_{pm} = 11.92$ *cal/g-mol-K*

Bago O_2*:* $C_{pm} = 7.941$ *cal/g-mol-K*

Bagi N_2*:* $C_{pm} = 7.507$ *cal/g-mol-K*

$$\Delta H = \Sigma(H_p + \Delta H_{25}) - \Sigma H_R$$

di mana ΣH_p = jumlah entalpi bagi semua hasil dari tindak balas, merujuk kepada keadaan standard pada 25°C.

ΔH_{25} = haba tindak balas standard.

ΣH_R = jumlah entalpi semua bahan tindak balas yang terlibat relatif dengan keadaan rujukan haba tindak balas standard, 25°C dan 1 atm.

Sila lihat lampiran untuk Data.

4. (a) Hitungkan haba tindak balas standard untuk tindak balas berikut:

$$HCl(g) + NH_3(g) = NH_4Cl(s)$$

HCl(g) $\Delta H_f = ?$
NH₃(g) $\Delta H_f = ?$
NH₄Cl(s) $\Delta H_f = ?$

$\therefore \Delta H_{25} = ?$

(b) Hitungkan haba tindak balas standard ΔH_{25} untuk tindak balas berikut.

$$2FeS_2(s) + 5.5O_2(g) = Fe_2O_3(s) + 4SO_2(g)$$

$FeS_2(s)$ $\Delta H_f = ?$
$Fe_2O_3(s)$ $\Delta H_f = ?$
$SO_2(g)$ $\Delta H_f = ?$

$\Delta H_{25} = ?$

(c) Hitungkan haba tindak balas standard ΔH_{25} untuk tindak balas berikut:

$$C_2H_5OH(l) + CH_3COOH(l) = C_2H_5COOCH_3(l) + H_2O(l)$$

C_2H_5OH $\Delta H_c = ?$
CH_3COOH $\Delta H_c = ?$
$C_2H_5COOCH_3$ $\Delta H_c = ?$

$\therefore \Delta H_{25} = ?$

$[\ \Delta H_{tindak\ balas} = \Sigma\Delta H_{c(bahan)} - \Sigma\Delta H_{c(hasil)}\ ]_{25oC}$

Sila lihat lampiran untuk Data.

5. (a) Penuhkan jadual berikut bagi air:

Suhu(°C)	Tekanan (kPa)	h (kJ/kg)	x (kualiti)	Penerangan Fasa
500		3420		
	600		0.3	
200	400			

(40 markah)

(b) Satu bekas tegar $0.4m^3$ pada mulanya mengandungi campuran cecair wap tepu H_2O pada 100°C. Air dipanaskan sehingga mencapai keadaan kritikal. Tentukan jisim cecair H_20 dan isipadu yang diambil oleh cecair H_2O pada keadaan mula. Lakarkan proses merujuk kepada garisan tepu.

(30 markah)

(c) Air tepu sebanyak 300g diwapkan sepenuhnya pada suhu malar 150°C. Tentukan

i) perubahan tenaga dalaman
ii) perubahan isipadu
iii) tekanan semasa proses ini berlaku
iv) lakarkan proses dalam gambarajah T-v merujuk kepada garisan tepu.

(30 markah)

6. (a) Tentukan isipadu spesifik bagi wap panas lampau (H_20) pada 15MPa dan 600°C menggunakan:

i) persamaan gas unggul
ii) jadual stim
iii) carta kebolehmampatan teritlak

Kaedah manakah akan memberi nilai yang paling jitu?

(40 markah)

(b) Satu campuran gas yang terdiri daripada 15 lb N_2 dan 20 lb H_2 berada pada tekanan 50 psig dan suhu 60°F. Tentukan yang berikut dengan menganggap bahawa campuran ini adalah unggul.

(a) tekanan separa bagi setiap komponen
(b) isipadu spesifik bagi campuran
(c) ketumpatan campuran

(40 markah)

(c) Satu gas memenuhi 1 m^3 pada tekanan piawai dikembangkan kepada $1.2m^3$, pada suhu malar. Apakah nilai tekanan baru?

(20 markah)

Keadaan Standard Biasa bagi Gas Unggul

Sistem	T	p	$\hat{V}$
SI	273.15K	101.325 kPa	22.415 m^3/kg mol
Universal scientific	0.0°C	760 mm Hg	22.415 liters/g mol
Natural gas industry	60.0°C	14.696 psia	379.4 ft^3/lb mol
		(15.0°C)	(101.325 kPa)
American engineering	32°F	1 atm	359.05 ft^3/lb mol

FIGURE A-30*b*

Nelson–Obert generalized compressibility chart—*intermediate pressures*. (Used with permission of Dr. Edward E. Obert, University of Wisconsin.)

Z

(*b*) $0 < P_r < 7$

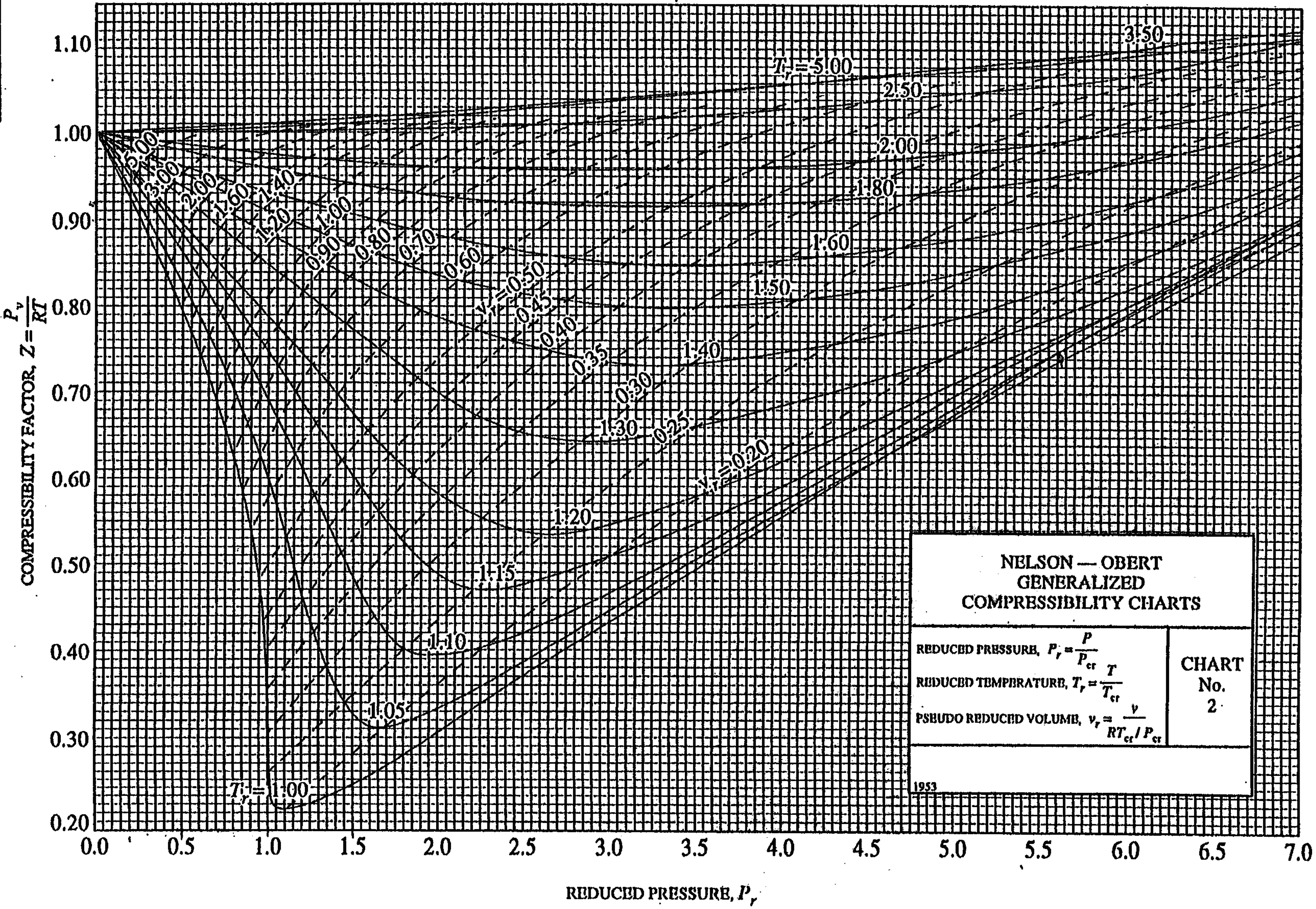
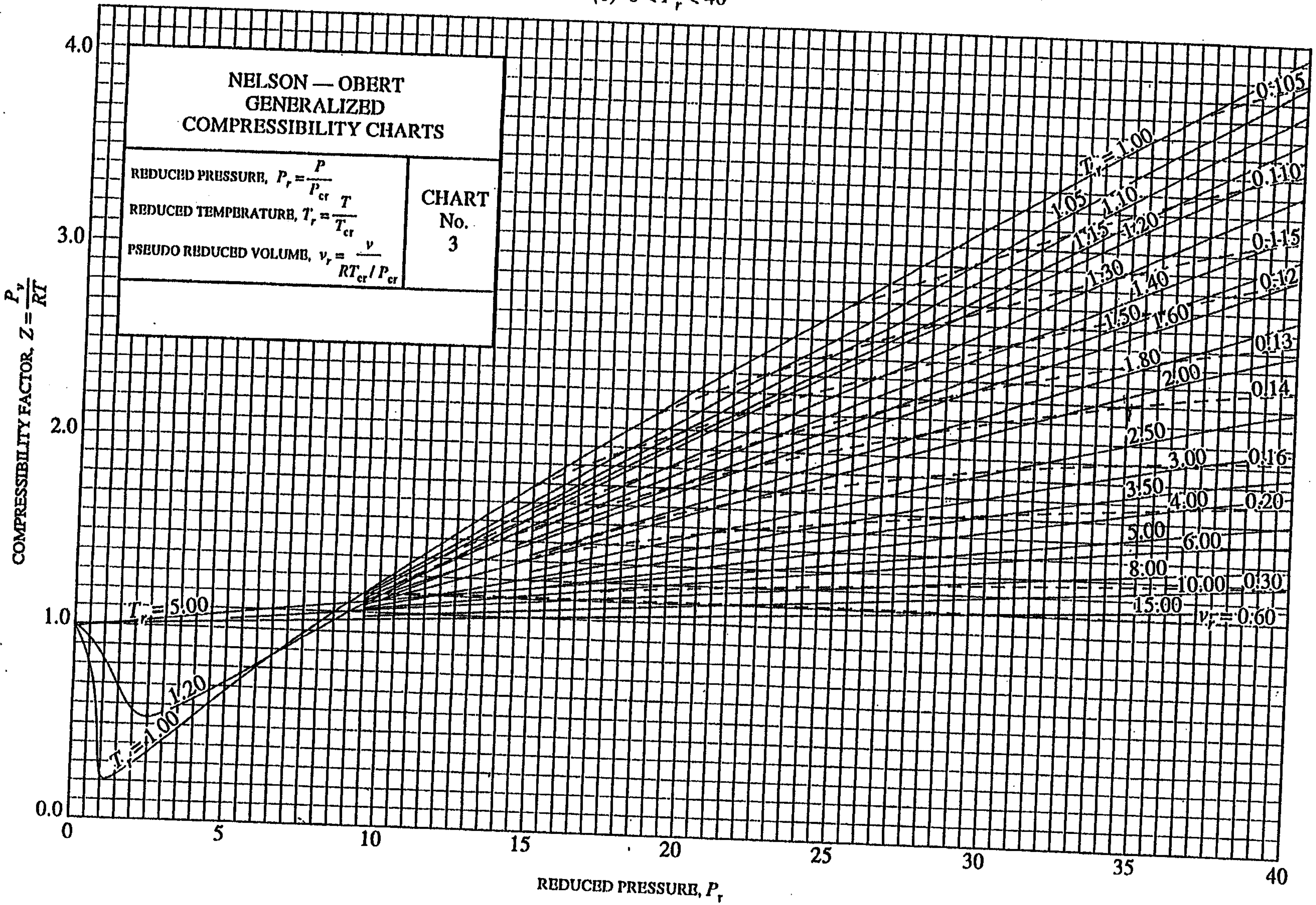


FIGURE A-30c

Nelson–Obert generalized compressibility chart—*high pressures*. (Used with permission of Dr. Edward E. Obert, University of Wisconsin.)

(c) $0 < P_r < 40$



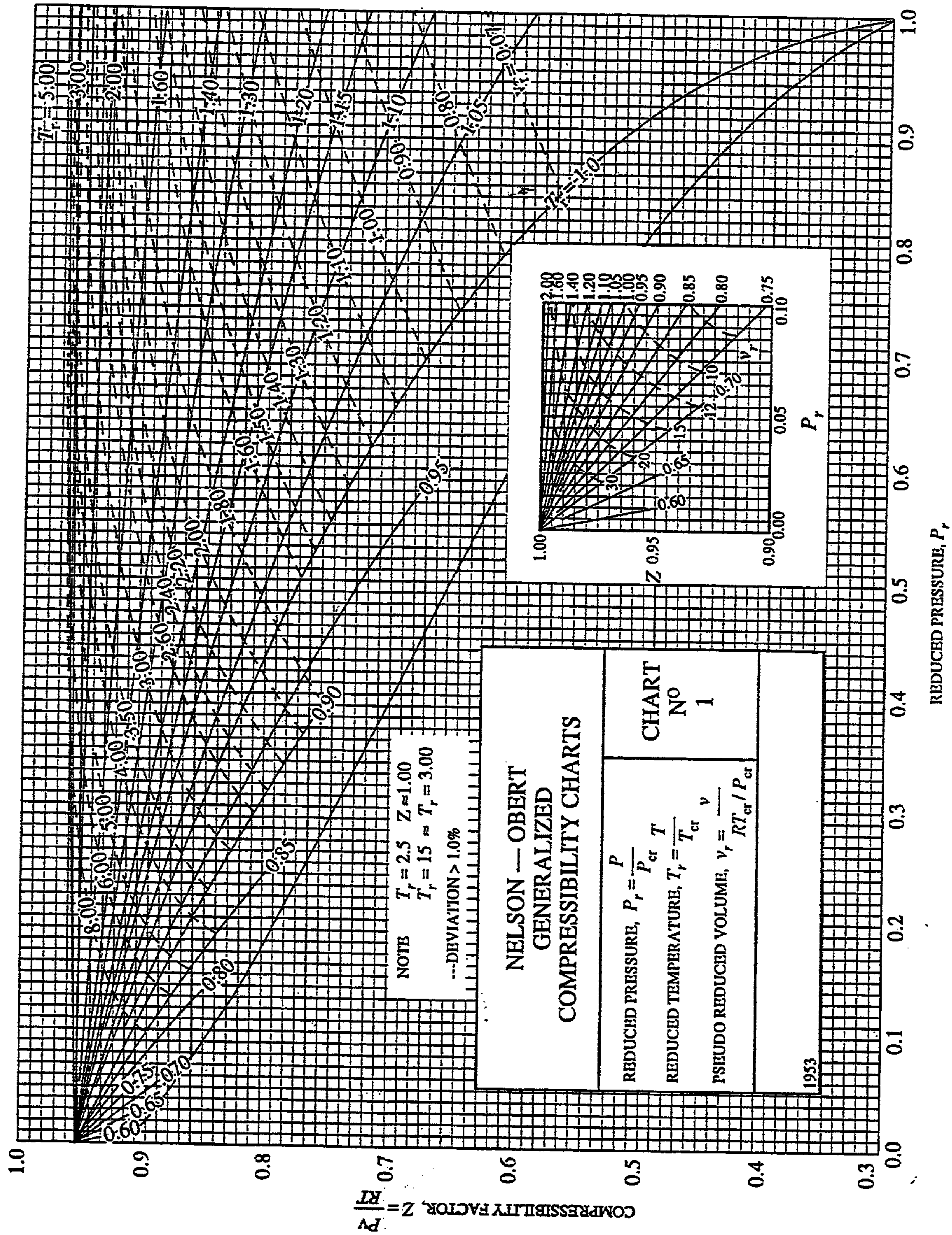

NELSON — OBERT
GENERALIZED
COMPRESSIBILITY CHARTS
CHART
No
1
REDUCED PRESSURE, $P_r = \frac{P}{P_{cr}}$
REDUCED TEMPERATURE, $T_r = \frac{T}{T_{cr}}$
PSEUDO REDUCED VOLUME, $v_r = \frac{v}{RT_{cr}/P_{cr}}$
1953
NOTE $T_r = 2.5$ $Z \approx 1.00$
$T_r = 15 \approx T_r = 3.00$
--DEVIATION > 1.0%
REDUCED PRESSURE, P_r
COMPRESSIBILITY FACTOR, $Z = \frac{PV}{RT}$

TABLE HEATS OF FORMATION AND SOLUTION

Reference Conditions: 25° C (298.16° K), 1 atm pressure, gaseous substances in ideal state.

ΔH°_f = standard heat of formation, kcal per g-mole
ΔH°_s = standard integral heat of solution, kcal per g-mole

Multiply values by 1000 to obtain g-cal per g-mole, or kcal per kg-mole.
Multiply values by 1800 to obtain Btu per lb-mole.

Source: *Selected Values of Chemical Thermodynamic Properties*, as of July 1, 1953, edited by D. D. Wagman, National Bureau of Standards.

Abbreviations

c	= crystalline state	∞	= infinite dilution
l	= liquid state	*ppt*	= precipitated solid
g	= gaseous state	*amorph*	= amorphous state
dil	= in dilute aqueous solution		

Compound	Formula	State	ΔH°_f, Heat of Formation	Moles of Water	ΔH°_s, Heat of Solution
Acetic acid	CH_3COOH	*l*	−116.4	∞	−0.343
Aluminum chloride	$AlCl_3$	*c*	−166.2	600	−79.3
Aluminum hydroxide	$Al(OH)_3$	*amorph*	−304.2		
Aluminum oxide	Al_2O_3	Corundum, *c*	−399.09		
Aluminum silicate	Al_2SiO_5	Sillimanite, *c*	−648.9		
Aluminum sulfate	$Al_2(SO_4)_3$	*c*	−820.98	∞	−76.12
Ammonia	NH_3	*g*	−11.04	∞	−8.28
Ammonia	NH_3	*l*	−16.06	∞	−3.26
Ammonium carbonate	$(NH_4)_2CO_3$	*dil*	−225.11		
Ammonium bicarbonate	$(NH_4)HCO_3$	*c*	−203.7	∞	+6.78
Ammonium chloride	NH_4Cl	*c*	−75.38	∞	+3.62
Ammonium hydroxide	NH_4OH	*in* 1 H_2O	−87.64		
Ammonium nitrate	NH_4NO_3	*c*	−87.27	∞	+6.16
Ammonium oxalate	$(NH_4)_2C_2O_4$	*c*	−268.72	2100	+8.12
Ammonium sulfate	$(NH_4)_2SO_4$	*c*	−281.86	∞	+1.48
Ammonium acid sulfate	$(NH_4)HSO_4$	*c*	−244.83	800	−0.76
Antimony trioxide	Sb_2O_3	*c*	−168.4	∞	+1.9
Antimony pentoxide	Sb_2O_5	*c*	−234.4	∞	+8.0
Antimony sulfide	Sb_2S_3	*c*	−43.5		
Arsenic acid	H_3AsO_4	*c*	−215.2	∞	+0.4
Arsenic trioxide	As_2O_3	*monoclinic, c*	−156.4	∞	+6.7
Arsenic pentoxide	As_2O_5	*c*	−218.6	∞	−6.0
Arsine	AsH_3	*g*	41.0		
Barium acetate	$Ba(C_2H_3O_2)_2$	*c*	−355.1	400	−6.4
Barium carbonate	$BaCO_3$	*c*	−291.3		
Barium chlorate	$Ba(ClO_3)_2$	*c*	−181.7	∞	+6.1
Barium chloride	$BaCl_2$	*c*	−205.56	∞	−3.16
Barium chloride	$BaCl_2 \cdot 2H_2O$	*c*	−349.35	∞	+4.00
Barium hydroxide	$Ba(OH)_2$	*c*	−226.2	∞	−12.38
Barium oxide	BaO	*c*	−133.4	∞	−36.9
Barium peroxide	BaO_2	*c*	−150.5		
Barium silicate	$BaSiO_3$	*c*	−359.5		
Barium sulfate	$BaSO_4$	*c*	−350.2	∞	+4.63
Barium sulfide	BaS	*c*	−106.0	∞	−12.4
Bismuth oxide	Bi_2O_3	*c*	−137.9		
Boric acid	H_3BO_3	*c*	−260.2	∞	+5.0
Boron oxide	B_2O_3	*c*	−302.0	∞	−3.46
Bromine chloride	$BrCl$	*g*	+3.51		
Cadmium chloride	$CdCl_2$	*c*	−93.0	∞	−4.39
Cadmium oxide	CdO	*c*	−60.86		

Compound	Formula	State	ΔH°f, Heat of Formation	Moles of Water	ΔH°s, Heat of Solution
Cadmium sulfate	$CdSO_4$	c	−221.36	∞	−12.84
Cadmium sulfide	CdS	c	−34.5		
Calcium acetate	$Ca(C_2H_3O_2)_2$	c	−355.0	∞	−7.5
Calcium aluminate	$CaO{\cdot}Al_2O_3$	glass	−545		
Calcium aluminate	$2CaO{\cdot}Al_2O_3$	glass	−695		
Calcium aluminate	$3CaO{\cdot}Al_2O_3$	glass	−848		
Calcium aluminum silicate	$3CaO{\cdot}Al_2O_3{\cdot}2SiO_2$	c	−1303		−7.5
Calcium aluminum silicate	$CaO{\cdot}Al_2O_3{\cdot}6SiO_2$	c	−1828		
Calcium carbide	CaC_2	c	−15.0		
Calcium carbonate	$CaCO_3$	Calcite, c	−288.45		
Calcium chloride	$CaCl_2$	c	−190.0	∞	−19 82
Calcium chloride	$CaCl_2{\cdot}6H_2O$	c	−623.15	∞	+3.43
Calcium fluoride	CaF_2	c	−290.3		
Calcium hydroxide	$Ca(OH)_2$	c	−235.80	∞	−3.88
Calcium nitrate	$Ca(NO_3)_2$	c	−224.0	∞	−4.51
Calcium oxalate	$CaC_2O_4{\cdot}H_2O$	c	−399.1		
Calcium oxide	CaO	c	−151.9	∞	−19.46
Calcium phosphate	$Ca_3(PO_4)_2$	c, α	−986.2		
Calcium silicate	$CaSiO_3$	(Wallastonite, c)	−378.6		
Calcium silicate	Ca_2SiO_4	c, β	−538.0		
Calcium sulfate	$CaSO_4$	Anhydrite, c	−342.42	∞	−4.25
Calcium sulfide	CaS	c	−115.3	∞	−4.5
Carbon graphite	C	c	0		
Diamond	C	c	+0.4532		
Amorphous (in coke)	C	amorph	+2.6		
Carbon monoxide	CO	g	−26.4157		
Carbon dioxide	CO_2	g	−94.0518	∞	−4.64
Carbon disulfide	CS_2	g	+27.55		
Carbon disulfide	CS_2	l	+21.0		
Carbon tetrachloride	CCl_4	g	−25.50		
Carbon tetrachloride	CCl_4	l	−33.34		
Chloric acid	$HClO_3$	dil	−23.50		
Chromium chloride	$CrCl_3$	c	−134.6		
Chromium chloride	$CrCl_2$	c	−94.56	∞	−18.64
Chromium oxide	Cr_2O_3	c	−269.7		
Chromium trioxide	CrO_3	c	−138.4	80	−2.5
Cobalt oxide	CoO	c	−57.2		
Cobalt oxide	Co_3O_4	c	−210		
Cobalt chloride	$CoCl_2$	c	−77.8		
Cobalt sulfide	CoS	ppt	−21.4		
Copper acetate	$Cu(C_2H_3O_2)_2$	c	−213.2	∞	−2.7
Copper carbonate	$CuCO_3$	c	−142.2		
Copper chloride	$CuCl_2$	c	−52.3	in aq. HCl	−6.3
Copper chloride	CuCl	c	−32.5		
Copper nitrate	$Cu(NO_3)_2$	c	−73.4	800	−10.4
Copper oxide	CuO	c	−37.1		
Copper oxide	Cu_2O	c	−39.84		
Copper sulfate	$CuSO_4$	c	−184.00	∞	−17.51
Copper sulfide	CuS	c	−11.6		
Copper sulfide	Cu_2S	c	−19.0		
Cyanogen	C_2N_2	g	+73.60		
Hydrobromic acid	HBr	g	−8.66	∞	−20.24
Hydrochloric acid	HCl	g	−22.063	∞	−17.960
Hydrocyanic acid	HCN	g	+31.2	∞	−6.0
Hydrofluoric acid	HF	g	−64.2	∞	−14.46

...14/-

Compound	Formula	State	ΔH°_f, Heat of Formation	Moles of Water	ΔH°_s, Heat of Solution
Hydriodic acid	HI	*g*	+6.20	∞	−19.57
Hydrogen oxide	H_2O	*g*	−57.7979		
Hydrogen oxide	H_2O	*l*	−68.3174		
Hydrogen oxide (heavy water)	D_2O	*g*	−59.5628		
Hydrogen oxide (heavy water)	D_2O	*l*	−70.4133		
Hydrogen peroxide	H_2O_2	*l*	−44.84	∞	−0.84
Hydrogen sulfide	H_2S	*g*	−4.815	∞	−4.58
Iron acetate	$Fe(C_2H_3O_2)_3$	*in 1800* H_2O	−353.8		
Iron carbide	Fe_3C	*c*	+5.0		
Iron carbonate	$FeCO_3$	*c*	−178.70		
Iron chloride	$FeCl_2$	*c*	−81.5	∞	−19.5
Iron chloride	$FeCl_3$	*c*	−96.8	∞	−31.1
Iron hydroxide	$Fe(OH)_2$	*c*	−135.8		
Iron hydroxide	$Fe(OH)_3$	*c*	−197.0		
Iron nitride	Fe_4N	*c*	−2.55		
Iron oxide	FeO	*c*	−64.3		
Iron oxide	$Fe_{0.95}O$	Wustite, *c*	−63.7		
Iron oxide	Fe_3O_4	*c*	−267.0		
Iron oxide	Fe_2O_3	*c*	−196.5		
Iron silicate	$FeO \cdot SiO_2$	*c*	−276		
Iron silicate	$2FeO \cdot SiO_2$	*c*	−343.7		
Iron sulfate	$Fe_2(SO_4)_3$	*in 3000* H_2O	−653.62		
Iron sulfate	$FeSO_4$	*c*	−220.5	200	−15.5
Iron sulfide	FeS	*c*	−22.72		
Iron sulfide	FeS_2	Pyrites, *c*	−42.52		
Lead acetate	$Pb(C_2H_3O_2)_2$	*c*	−230.5	∞	−2.1
Lead carbonate	$PbCO_3$	*c*	−167.3		
Lead chloride	$PbCl_2$	*c*	−85.85	∞	+6.20
Lead nitrate	$PbNO_3$	*c*	−107.35	∞	+9.00
Lead oxide (yellow)	PbO	*c*	−52.07		
Lead peroxide	PbO_2	*c*	−66.12		
Lead suboxide	Pb_2O	*c*	−51.2		
Lead sesquioxide	Pb_3O_4	*c*	−175.6		
Lead sulfate	$PbSO_4$	*c*	−219.50		
Lead sulfide	PbS	*c*	−22.54		
Lithium chloride	$LiCl$	*c*	−97.70	∞	−8.377
Lithium hydroxide	$LiOH$	*c*	−116.45	∞	−5.061
Magnesium carbonate	$MgCO_3$	*c*	−266		
Magnesium chloride	$MgCl_2$	*c*	−153.40	∞	−37.06
Magnesium hydroxide	$Mg(OH)_2$	*c*	−221.00		
Magnesium oxide	MgO	*c*	−143.84		
Magnesium silicate	$MgSiO_3$	*c*	−357.9		
Magnesium sulfate	$MgSO_4$	*c*	−305.5	∞	−21.81
Manganese carbonate	$MnCO_3$	*c*	−213.9		
Manganese carbide	Mn_3C	*c*	−1		
Manganese chloride	$MnCl_2$	*c*	−115.3	400	−16.7
Manganese oxide	MnO	*c*	−92.0		
Manganese oxide	Mn_3O_4	*c*	−331.4		
Manganese oxide	Mn_2O_3	*c*	−232.1		
Manganese dioxide	MnO_2	*c*	−124.5		
Manganese dioxide	MnO_2	*amorph*	−117.0		
Manganese silicate	$MnO \cdot SiO_2$	*c*	−302.5		
Manganese silicate	$MnO \cdot SiO_2$	*glass*	−294.0		
Manganese sulfate	$MnSO_4$	*c*	−254.24	∞	−14.96
Manganese sulfide	MnS	*c*	−48.8		

...15/-

Compound	Formula	State	ΔH°_f, Heat of Formation	Moles of Water	ΔH°_s, Heat of Solution
Mercury acetate	$Hg(C_2H_3O_2)_2$	*c*	−199.4	∞	+4.2
Mercury bromide	$HgBr_2$	*c*	−40.5	∞	+3.4
Mercury chloride	$HgCl_2$	*c*	−55.0	∞	+3.2
Mercury chloride	Hg_2Cl_2	*c*	−63.32		
Mercury nitrate	$Hg(NO_3)_2$	*dil*	−58.0		
Mercury nitrate	$Hg_2(NO_3)_2 \cdot 2H_2O$	*c*	−206.9		
Mercury oxide	HgO	*red, c*	−21.68		
Mercury oxide	HgO	*yellow, c*	−21.56		
Mercury oxide	Hg_2O	*c*	−21.8		
Mercury sulfate	$HgSO_4$	*c*	−168.3		
Mercury sulfate	Hg_2SO_4	*c*	−177.34		
Mercury sulfide	HgS	Cinnabar, *c*	−13.90		
Mercury thiocyanate	$Hg(CNS)_2$	*c*	+48.0		
Molybdenum oxide	MoO_2	*c*	−130		
Molybdenum oxide	MoO_3	*c*	−180.33	∞	−7.77
Molybdenum sulfide	MoS_2	*c*	−55.5		
Nickel chloride	$NiCl_2$	*c*	−75.5	10,000	−19.63
Nickel cyanide	$Ni(CN)_2$	*c*	+27.1		
Nickel hydroxide	$Ni(OH)_2$	*c*	−162.1		
Nickel hydroxide	$Ni(OH)_2$	*c*	−128.6		
Nickel oxide	NiO	*c*	−58.4		
Nickel sulfide	NiS	*c*	−17.5		
Nickel sulfate	$NiSO_4$	*c*	−213.0	∞	−19.2
Nitrogen oxide	NO	*g*	+21.600		
Nitrogen oxide	N_2O	*g*	+19.49		
Nitrogen oxide	NO_2	*g*	+8.091		
Nitrogen pentoxide	N_2O_5	*g*	+3.6	∞	−34.03
Nitrogen pentoxide	N_2O_5	*c*	−10.0	∞	−20.43
Nitrogen tetroxide	N_2O_4	*g*	+2.309		
Nitrogen trioxide	N_2O_3	*g*	+20.0		
Nitric acid	HNO_3	*l*	−41.404	∞	−7.968
Oxalic acid	$H_2C_2O_4 \cdot 2H_2O$	*c*	−340.9	2100	+8.70
Oxalic acid	$H_2C_2O_4$	*c*	−197.6	2100	+2.03
Perchloric acid	$HClO_4$	*l*	−11.1	∞	−20.31
Phosphoric acid (meta)	HPO_3	*c*	−228.2	∞	−6.7
Phosphoric acid (ortho)	H_3PO_4	*c*	−306.2	3000	−3.2
Phosphoric acid (pyro)	$H_4P_2O_7$	*c*	−538.0	∞	−7.9
Phosphorous acid (hypo)	H_3PO_2	*l*	−143.2	∞	−2.4
Phosphorous acid (ortho)	H_3PO_3	*l*	−229.1	∞	−3.1
Phosphorus trichloride	PCl_3	*g*	−73.22		
Phosphorus pentoxide	P_2O_5	*c*	−360.0		
Platinum chloride	$PtCl_4$	*c*	−62.9	∞	−19.5
Platinum chloride	PtCl	*c*	−17.7		
Potassium acetate	$KC_2H_3O_2$	*c*	−173.2	∞	−3.68
Potassium carbonate	K_2CO_3	*c*	−273.93	1000	−7.63
Potassium chlorate	$KClO_3$	*c*	−93.50	∞	+9.96
Potassium chloride	KCl	*c*	−104.175	∞	+4.115
Potassium chromate	K_2CrO_4	*c*	−330.49	∞	+4.49
Potassium cyanide	KCN	*c*	−26.90	∞	+2.80
Potassium dichromate	$K_2Cr_2O_7$	*c*	−485.90	2000	+17.20
Potassium fluoride	KF	*c*	−134.46	∞	−4.24
Potassium nitrate	KNO_3	*c*	−117.76	∞	+8.35
Potassium oxide	K_2O	*c*	−86.4	∞	−75.28
Potassium sulfate	K_2SO_4	*c*	−342.66	∞	+5 68
Potassium sulfide	K_2S	*c*	−100	400	−9.9
Potassium sulfite	K_2SO_3	*c*	−266.9	∞	−2.2
Potassium thiosulfate	$K_2S_2O_3$	*aq*	−274		

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Compound	Formula	State	ΔH°_f, Heat of Formation	Moles of Water	ΔH°_s, Heat of Solution
Potassium hydroxide	KOH	*c*	−101.78	∞	−13.22
Potassium nitrate	KNO_3	*c*	−117.76	∞	+8.348
Potassium permanganate	$KMnO_4$	*c*	−194.4	4000	+10.5
Selenium oxide	SeO_2	*c*	−55.0	∞	+0.93
Silicon carbide	SiC	*c*	−26.7		
Silicon tetrachloride	$SiCl_4$	*l*	−153.0		
Silicon tetrachloride	$SiCl_4$	*g*	−145.7		
Silicon dioxide	SiO_2	Quartz, *c*	−205.4		
Silver bromide	$AgBr$	*c*	−23.78		
Silver chloride	$AgCl$	*c*	−30.362		
Silver nitrate	$AgNO_3$	*c*	−29.43	∞	+5.37
Silver sulfate	Ag_2SO_4	*c*	−170.50	∞	+4.50
Silver sulfide	Ag_2S	*α, c*	−7.60		
Sodium acetate	$NaC_2H_3O_2$	*c*	−169.8	∞	−4.322
Sodium arsenate	Na_3AsO_4	*c*	−365	500	−16.5
Sodium tetraborate	$Na_2B_4O_7$	*c*	−777.7	900	−10.2
Sodium borate	$Na_2B_4O_7 \cdot 10H_2O$	*c*	−1497.2	900	+26.1
Sodium bromide	$NaBr$	*c*	−86.030	∞	−0.15
Sodium carbonate	Na_2CO_3	*c*	−270.3	400	−5.6
Sodium carbonate	$Na_2CO_3 \cdot 10H_2O$	*c*	−975.6	400	+16.5
Sodium bicarbonate	$NaHCO_3$	*c*	−226.5	∞	+4.0
Sodium chlorate	$NaClO_3$	*c*	−85.73	∞	+4.95
Sodium chloride	$NaCl$	*c*	−98.232	∞	+0.930
Sodium cyanide	$NaCN$	*c*	−21.46	200	+0.26
Sodium fluoride	NaF	*c*	−136.0	∞	+0.06
Sodium hydroxide	$NaOH$	*c*	−101.99	∞	−10.246
Sodium iodide	NaI	*c*	−68.84	∞	−1.81
Sodium nitrate	$NaNO_3$	*c*	−101.54	∞	−5.111
Sodium oxalate	NaC_2O_4	*c*	−314.3	600	+3.8
Sodium oxide	Na_2O	*c*	−99.4	∞	−56.8
Sodium triphosphate	Na_3PO_4	*c*	−460	1000	−13.9
Sodium diphosphate	Na_2HPO_4	*c*	−417.4	1000	−6.04
Sodium monophosphate	NaH_2PO_4	*in 300* H_2O	−367.7		
Sodium phosphite	Na_2HPO_3	*c*	−338	800	−9.5
Sodium selenate	Na_2SeO_4	*c*	−258	∞	−1.7
Sodium selenide	Na_2Se	*c*	−63.0	∞	−19.9
Sodium sulfate	Na_2SO_4	*c*	−330.90	∞	−0.56
Sodium sulfate	$Na_2SO_4 \cdot 10H_2O$	*c*	−1033.48	∞	+18.85
Sodium bisulfate	$NaHSO_4$	*c*	−269.2	200	−1.4
Sodium sulfide	Na_2S	*c*	−89.2	800	−15.16
Sodium sulfide	$Na_2S \cdot 4\frac{1}{2}H_2O$	*c*	−416.9	800	+5.11
Sodium sulfite	Na_2SO_3	*c*	−260.6	∞	−3.2
Sodium bisulfite	$NaHSO_3$	*dil*	−206.6		
Sodium silicate	Na_2SiO_3	*glass*	−360		
Sodium silicofluoride	Na_2SiF_6	*c*	−677	600	+5.8
Sulfur dioxide	SO_2	*g*	−70.96	10,000	9.90
Sulfur trioxide	SO_3	*g*	−94.45	∞	−54.13
Sulfuric acid	H_2SO_4	*l*	−193.91	∞	−22.99
Tellurium oxide	TeO_2	*c*	−77.69	∞	+1.31
Tin chloride	$SnCl_4$	*l*	−130.3	aq HCl	−29.9
Tin chloride	$SnCl_2$	*c*	−83.6	aq HCl	−0.4
Tin oxide	SnO_2	*c*	−138.8		
Tin oxide	SnO	*c*	−68.4		
Titanium oxide	TiO_2	*amorph*	−207		
Titanium oxide	TiO_2	Rutile, *c*	−218.0		
Tungsten oxide	WO_2	*c*	−136.3		
Vanadium oxide	V_2O_5	*c*	−373		
Zinc acetate	$Zn(C_2H_3O_2)_2$	*c*	−258.1	800	−9.8
Zinc bromide	$ZnBr_2$	*c*	−78.17	∞	−16.06
Zinc carbonate	$ZnCO_3$	*c*	−194.2		
Zinc chloride	$ZnCl_2$	*c*	−99.40	∞	−17.08
Zinc hydroxide	$Zn(OH)_2$	*c*	−153.5		
Zinc iodide	ZnI_2	*c*	−49.98	∞	−13.19
Zinc oxide	ZnO	*c*	−83.17		
Zinc sulfate	$ZnSO_4$	*c*	−233.88	∞	−19.45
Zinc sulfide	ZnS	*c*	−48.5		
Zirconium oxide	ZrO_2	*c*	−258.2		

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